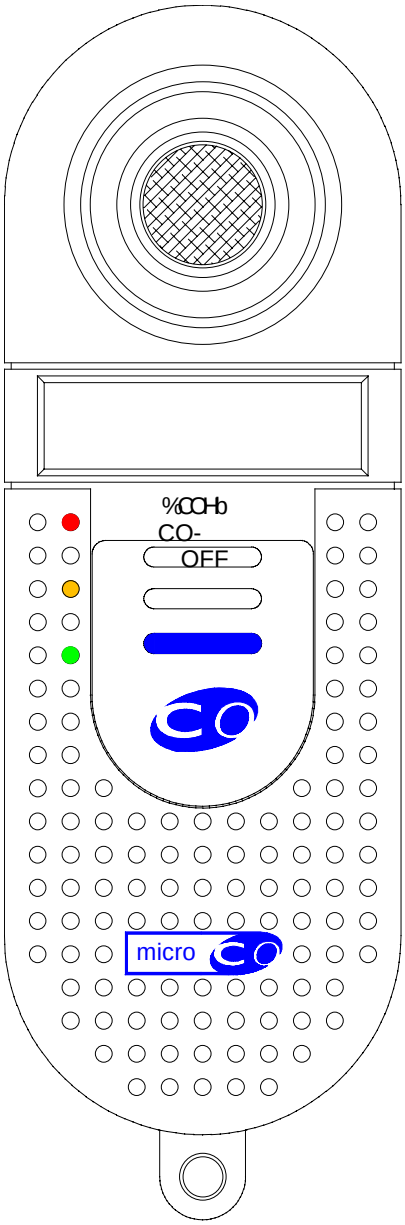


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# Micro CO Meter Service Manual

073-12 Iss. 1.1 Sept 2005

Micro Medical

# Micro CO Meter

# Service Manual

Information in this document is subject to change without notice and does not represent a commitment on the part of Micro Medical Limited. Only the parts supplied by Micro Medical Limited should be used to complete the service operation described in this manual. If in any way you feel unsure about the successful completion of the service operation you should contact Micro Medical Limited or its appointed agent in your country or region and arrange the despatch of the product to a Micro Medical Limited Service Centre.

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## Safety Precaution

The servicing of this device is intended to be carried out by a properly trained and competent electronics engineer, or experienced in the maintenance and servicing of medical devices. Read this manual thoroughly before proceeding with the service. If in any doubt please contact the service centre at Micro Medical Limited or their accredited agent in your country or region.

## Important Safeguards

- Read all of the instructions.
- Keep the instructions in a safe place for later use.
- Follow all warnings and instructions marked on the product.
- When replacement parts are required, be sure to use replacement parts specified by Micro Medical that have the same characteristics as the original parts. Unauthorised substitutions may result in fire, electric or other hazards.
- Do not place on an unstable table.
- The product should be operated only from the type of power source indicated on the label.

## Looking after your Micro CO Meter

- Avoid exposing the Micro CO Meter to solvents including alcohol and disinfectants.
- Avoid operating the Micro CO Meter in dusty conditions or near to heating appliances or radiators.
- Do not keep the Micro CO Meter in a damp place or expose it to extreme temperatures.

## Introduction

This service manual provides you with information to carry out the servicing of the Micro CO Meter. It is a process, which is relatively straightforward but must be carried out in a logical sequence. Our advice is to familiarise yourself with the contents of this manual before attempting to carry out the procedure of replacing the parts supplied in the sensor replacement kit for the Micro CO Meter.

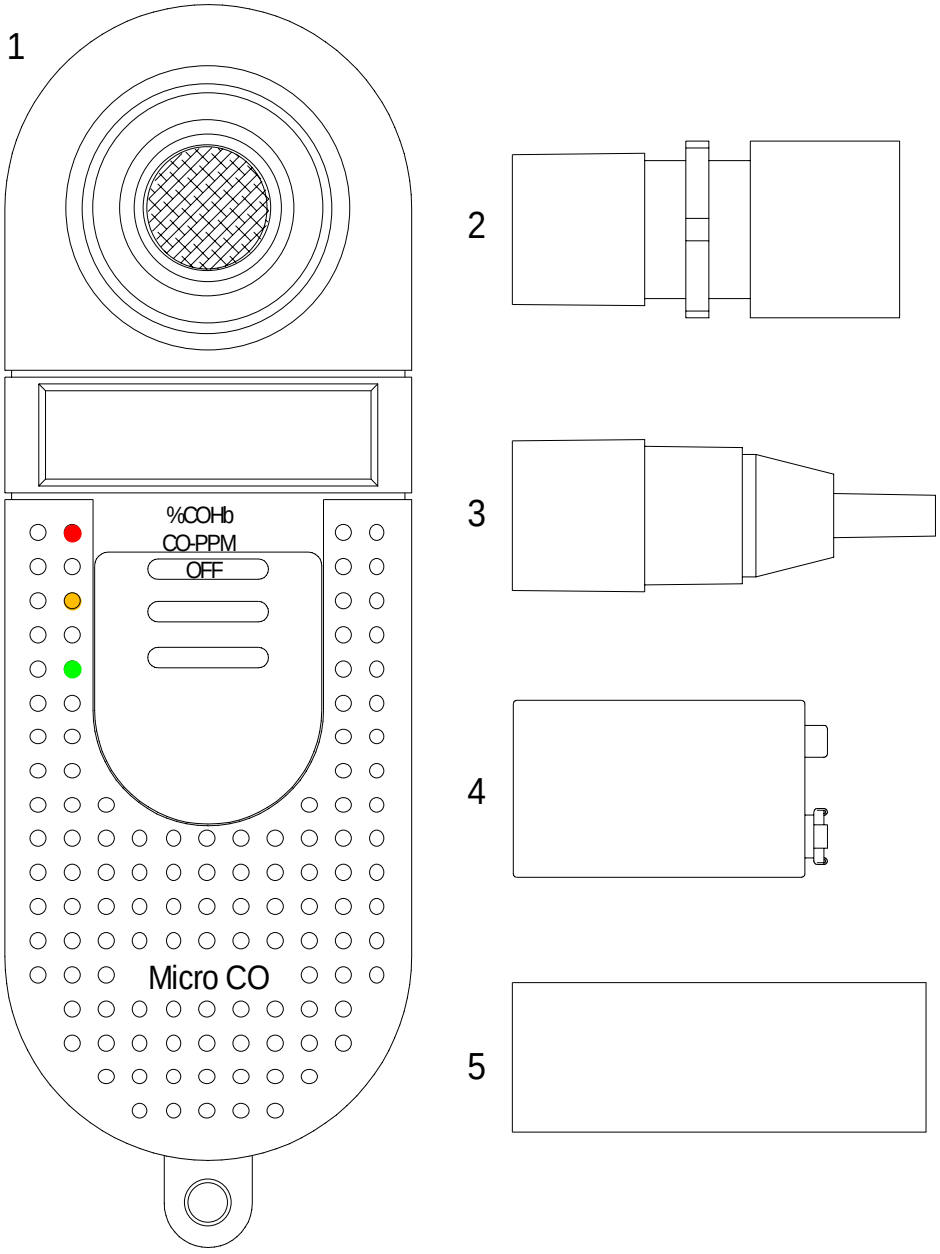
## Before You Begin

Before you begin the servicing operation, please read the section on Circuit description very carefully:

## Micro CO Meter system overview.

The Micro Medical Micro CO meter consists of a hand held microcomputer unit (1) incorporating a CO sensor and is supplied with a mouthpiece adapter with integral one way valve (2) together with disposable cardboard mouthpieces (5).

The microcomputer unit is powered by a single alkaline PP3 battery (4) and is supplied with a reducing connector for calibration (3).



The CO sensor is an electrochemical fuel cell, and works through the reaction of carbon monoxide at one electrode and oxygen (from ambient air) at the other. This reaction generates an electrical current proportional to the concentration of CO exposed to the sensing surface of the fuel cell.

The current output signal from the sensor is conditioned using a current to voltage converter and is applied to an analogue to digital (A/D) converter.

When the unit is first switched on the microprocessor records the baseline reading on the A/D input and uses this value to auto zero the instrument.

The subject is requested to breathe in maximally, hold the breath for 10 seconds, and then to expire fully through the mouthpiece connected to the microcomputer unit with the mouthpiece adapter. As an aid to timing the breath holding period a countdown from 10 to 0 is displayed after the unit is turned on.

The microprocessor then records the peak value obtained and displays this on a 3½ digit LCD display.

The value can be displayed either as parts per million (ppm) concentration in the expired air or as the equivalent percentage carboxyhaemoglobin (%COHb) using the mathematical relationships described by Jarvis et al, for concentrations below 90ppm and by Stewart et al for higher concentrations.

**Jarvis MJ, Belcher M, Vesey C, Hutchison DCS**

Low cost carbon monoxide monitors in smoking assessment.

Thorax 1986; 41:886-887

**Stewart RD, Stewart RS, Stamm W, Seleen RP**

Rapid estimation of carboxyhaemoglobin levels in fire fighters

JAMA 1976; 235:390-392

As a quick guide to the estimated smoking level, red, amber and green indicator lights are provided. The following levels of CO activate these lights:

| CO(ppm) | %COHb | Cigarette consumption | Indicator |
|---|---|---|---|
| 0 - 5 | 0 - 0.8 | Non smoker | Green |
| 6 - 10 | 1 - 1.6 | Light smoker | Amber |
| 11 - 72 | 1.8 - 12 | Heavy smoker | Red |
| >72 | >12 | Suspected poisoning | Red + alarm |

## CO Sensor

The sensor is an electrochemical micro fuel cell using gaseous diffusion barrier technology resulting in a direct response to volume concentration rather than partial pressure.

The cell consists of a working electrode and a counter electrode separated by a thin layer of electrolyte. The gaseous diffusion barrier limits the flow of gas to the sensing electrode and ensures the electrochemical activity of the electrode is far in excess of the amount of gas with which it has to deal.

Gas diffusing onto the working electrode reacts at the surface of the electrode by oxidation.

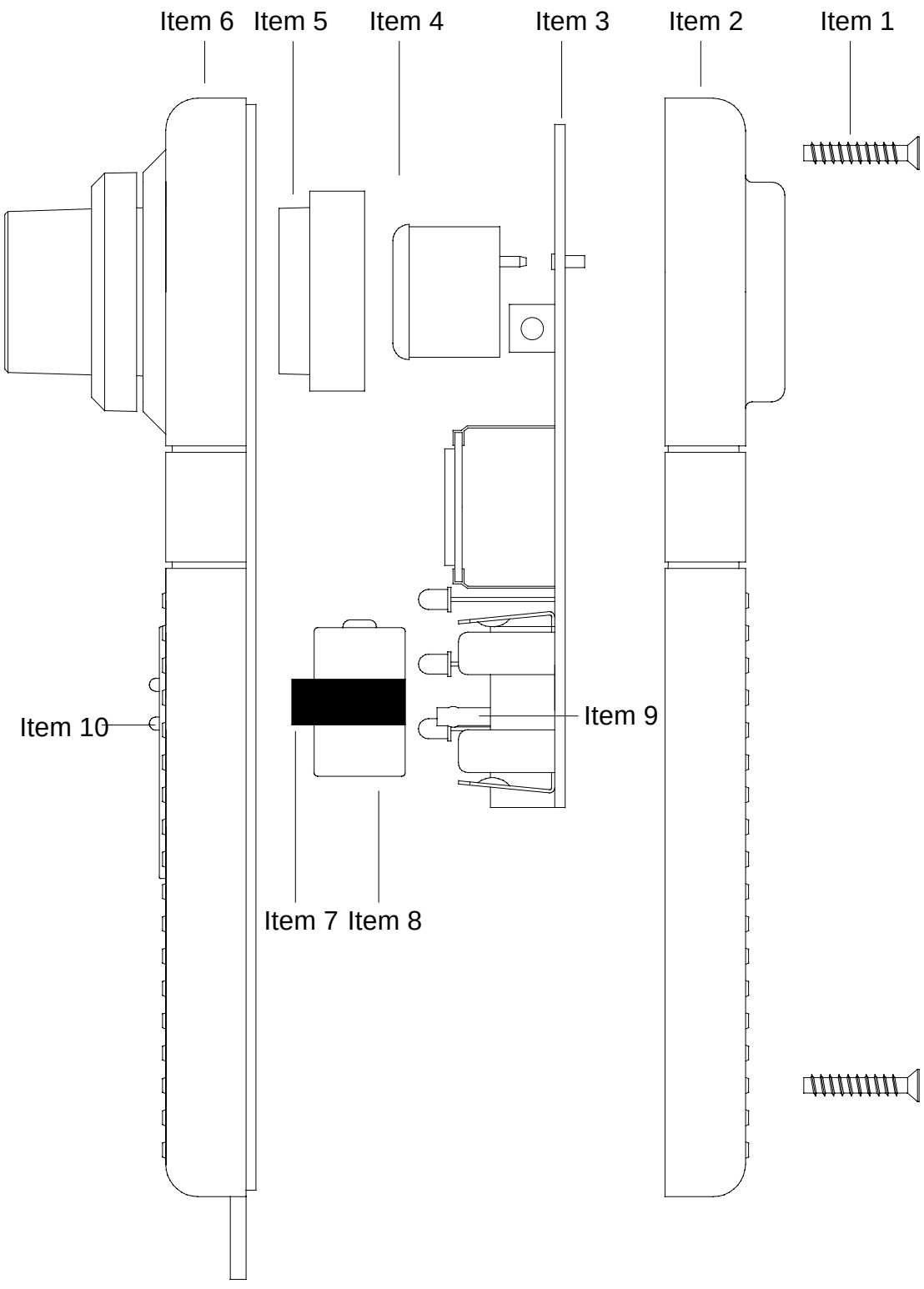
CO reacts at the working electrode according to the equation:

$$\mathbf{CO + H_2O \rightarrow CO_2 + 2H^+ + 2e^-}$$

The counter electrode acts to balance out the reaction at the sensing electrode by reducing oxygen in air to water:

$$\mathbf{\tfrac{1}{2}O_2 + 2H^+ + 2e^- \rightarrow 2\ H_2O}$$

## Micro CO meter exploded view



## Disassembling the Micro CO meter for servicing.

The Micro CO microcontroller unit comprises of a solid state electronic circuit in a robust ABS housing and does not require any preventative maintenance.

Routine maintenance consists of replacing the fuel cell and internal lithium battery when they are exhausted. The 3.6 volt lithium battery is continuously monitored by the microcontroller and the message **bt2** will be displayed when the voltage falls below 3 volts. The fuel cell exhibits a gradual loss of sensitivity with time and has effectively expired when the unit can no longer be calibrated.

When either the fuel cell or the lithium battery has expired, replace by following the procedure below.

1. Turn the unit face down and slide back the battery compartment.
2. Remove the PP3 battery.
3. Remove the 2 self tapping screws (Item 1) and put to one side.
4. Lift the top moulding (Item 6) from the bottom moulding (Item 2).
5. Remove the PCB (Item 3) from the bottom moulding.
6. If the fuel cell (Item 4) is exhausted carefully remove by gently pulling away from the PCB.
7. If the battery (Item 8) has expired, then note the orientation and remove from the PCB-mounted clips by pulling on the battery strap (Item 7) directly away from the PCB. Put the battery strap to one side and discard the battery.

## Replacing internal battery of the Micro CO.

1 Place the battery strap over the new battery (Cat No: BAT5900) and push into the PCB-mounted clips ensuring the correct orientation. **(Take great care not to short circuit the terminations even momentarily as the low internal impedance of lithium batteries will result in a high current consumption and greatly reduced life).**

## Replacing fuel cell of the Micro CO.

1 Remove the CO sensor (Cat No: CEL7300) from the plastic container.

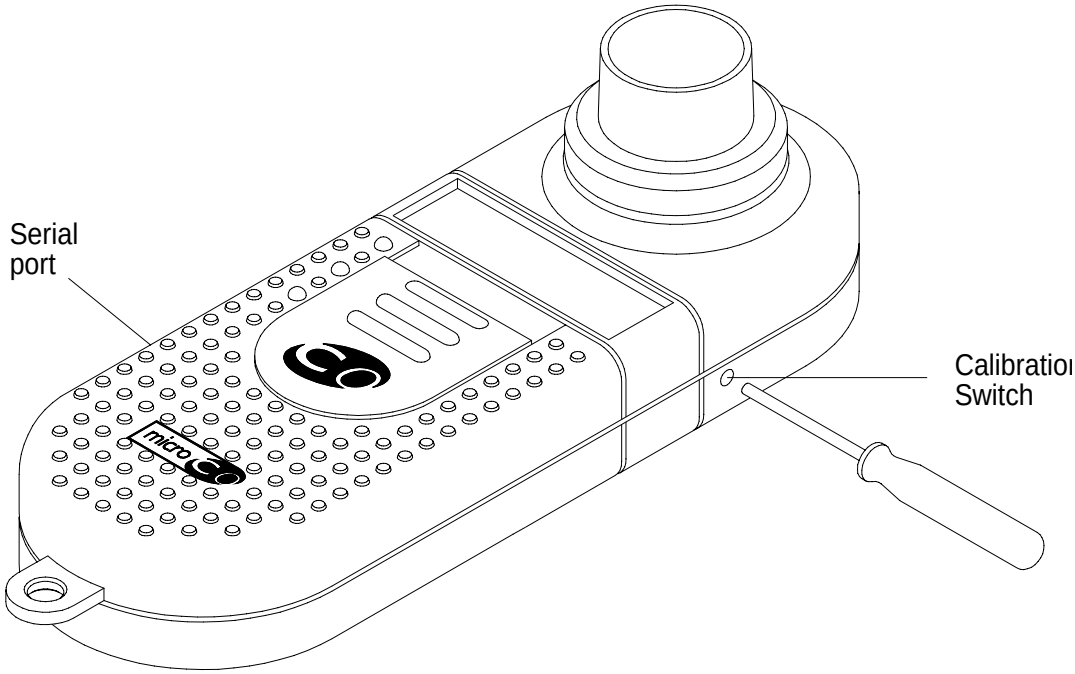
2 Carefully insert the CO cell into the PCB with the correct orientation.

## Reassembling the Micro CO meter

1. Place the PCB into the bottom moulding.
2. Tuck the battery strap between the battery and the side wall of the bottom moulding, away from the slide switch.
3. Ensure that the slide switch (Item 9) and the switch plate on the top moulding (item10) are both positioned at the bottom of their travel.
4. Ensure that the rubber gasket (Item 5) is in place in the top moulding.
5. Place the top moulding on top of the bottom moulding ensuring the rubber gasket fits over the cell correctly and secure using the two self-tapping screws.
6. Reconnect the PP3 battery ensuring correct polarity.

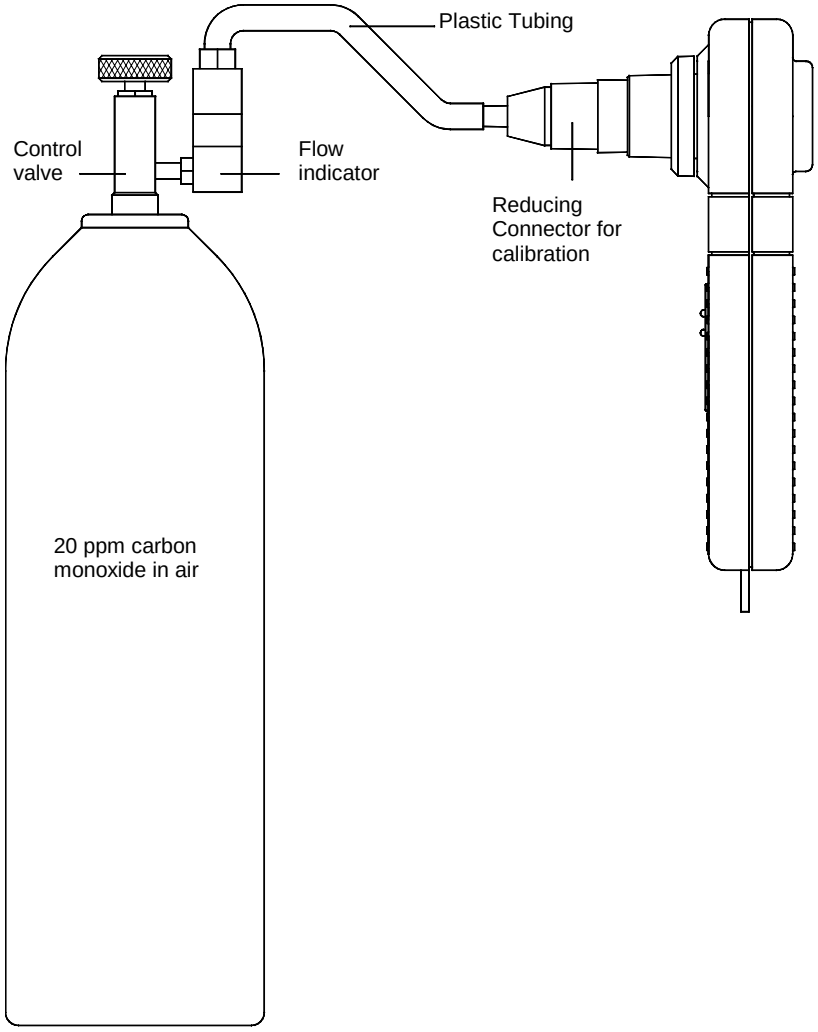
## Calibrating the CO meter

Calibration will remain stable to within 2% over one month and typically to within 10% over 6 months. Micro Medical supplies calibration gas (20ppm CO in air) and recommends that the unit is recalibrated on a 6 monthly basis. See page 13 for calibration accessories.
To carry out the calibration locate the calibration switch on the right hand side of the instrument as shown below.




Push the slide switch to the CO - PPM position and wait for the unit to display zero.

Screw the control valve firmly onto the cylinder and connect the gas supply as shown below:




The plastic tubing supplied with the gas should be pushed firmly over the reducing connector.
Slowly turn the control knob anti-clockwise until the ball in the flow indicator is between the two marks. This will then supply a gas flow of approximately 0.25 l/min. Apply this flow for 25 seconds and if the meter does not read 20ppm use the calibration tool to push the calibration switch.
The unit will then beep 3 times, store the new calibration value, and display the following:

The gas supply should then be turned off.

# Circuit description

(Refer to the parts list and circuit diagram)
The circuit is based on the Hitachi one time programmable (OTP) microcontroller HD64F3687FP (U5) operating at a clock frequency of 14.745MHz.
This processor contains EPROM, RAM, and eight 10-bit analogue to digital (A/D) converters. The current output signal from the sensor is conditioned using a current to voltage converter and is applied to an A/D input of the microcontroller. Voltages derived from the external PP3 battery and the internal lithium battery are also connected to the A/D converter inputs.
When the unit is first switched on the microprocessor records the baseline reading from the A/D and uses this value to auto-zero the instrument. The signal from the CO sensor is continuously monitored and the peak of the calculated carbon monoxide concentration is displayed and transmitted through the RS232 driver (U7).

## Power Supply

The unit has two separate supplies. The externally accessible alkaline 9 volt PP3 battery (BAT 1) provides the main supply. The instrument may be switched on and off with the slide switch and may also be switched off by a signal from the processor. This is done if the unit is left on, without use, for a period of 4 minutes in order to conserve battery power. The supply is controlled by gates U2 and U3 arranged in a bi-stable configuration, and powered continuously from BAT1. When the slide switch is moved to the 'CO-PPM' position one end of R7 is pulled low. This transition is differentiated by the action of C15 and R6 so that a momentary pulse appears on pin 2 of U3. This pulse will toggle the bi-stable circuit so that pin 4 of U2 will go low, turning transistor TR2 on, and supplying 9 volts to the low drop-out regulator, U4. When the slide switch is returned to the 'off' position pin 1 of U2 is pulled low, the bi-stable action is reversed, and TR2 will be turned off. If the unit is left on without use for approximately 4 minutes then pin 44 of U5 is driven high, under software control, turning on TR1 which will also turn the unit off via the bi-stable circuit. When this happens the slide switch must be pushed to the 'off' position and then to the 'CO-PPM' position in order to initiate another pulse through C15 to turn the unit back on again. The output of the 5 volt regulator supplies the processor and associated circuitry. C13 and C14 smooth the input and output of U4.
BAT1 is monitored by an A/D input of the microcontroller, pin 62 through the potential divider, R13 and R14. When this battery falls below 6.6 volts a battery low warning is temporarily indicated on the display upon switch on. When the battery falls below 6.1 volts the message is displayed permanently and the unit cannot be used.

The secondary power supply is provided by a single 3.6 volt lithium cell, BAT2, used to permanently power the fuel cell amplifier circuit consisting of the op-amp U1 and associated passive circuitry. The amplifier circuit draws less than 11uA from the 1000mA-Hr lithium battery giving a nominal operational life of greater than 10 years.
BAT2 is buffered by U8B and monitored by an A/D input of the microcontroller, pin 63. R27, between BAT2 and the inverting amplifier, prevents the battery from discharging through the op-amp when the supply is switched off. The battery has an end point of 3 volts and when this level is reached the message bt2 will be displayed. When this happens follow the procedure outlined in Servicing.

## Fuel cell amplifier circuit.

The fuel cell provides an output current, from the counter electrode, proportional to the concentration of target gas at the sensing surface. This current is converted to a voltage by the action of U1 and the associated passive components at a nominal transfer factor of 387mV/μA. This signal is further amplified by U8A with a gain of 2.08 and applied the A/D input of the microcontroller, pin 44, after being filtered by the action of R8 and C4. The sensitivity of the CO fuel cell is 0.045 +/- 0.015μA giving a nominal amplified output of 36mV/ppm CO.

## Reset Circuit

This microcontroller has internal reset circuitry that requires C12 and D5 for proper operation.

## Display

The display is a custom 3½ digit low power LCD. The segments and backplane are driven directly by microcontroller. The backplane is driven by a square wave of nominally 60Hz. The individual segments are driven by a similar square wave that is in phase with the backplane when the segment is off and 180 degrees out of phase when the segment is on.

## Sounder

The sounder is operated by a 1kHz square wave generated by pins 24 and 25 of U5.

## Indicator lights

The three indicator LED's are driven from pins 51, 52 and 53 of the microcontroller through transistors TR3, TR4 and TR5.

## RS232 interface

The transmit and receive ports for RS232 transmission are on pins 46 and 45 respectively of the microcontroller.  The transmission is converted from logic to RS232 levels by the U7.

## Specifications

| | |
|---|---|
| **Type** | Electro - chemical fuel cell |
| **Range** | 0 - 100ppm |
| **Resolution** | 1ppm |
| **Green indicator light** | 0 to 6ppm (0 to 1% COHb) |
| **Amber indicator light** | 7 to 10ppm (1.1 to 1.6% COHb) |
| **Red indicator light** | 11 to 72ppm (1.8 to 12% COHb) |
| **Flashing red light + alarm** | >72ppm (>12% COHb) |
| **Accuracy** | +/-5% of full scale of 1ppm whichever is the greater |
| **Sensitivity drift** | 0.5%/°C |
| **Sensor Life** | >2 to 5 years |
| **Response time** | <15 sec (to 90% of reading) |
| **Hydrogen cross sensitivity** | <15% |
| **Operating temperature** | 15 to 25°C |
| **Operating pressure** | Atmospheric +/-10% |
| **Pressure coefficient** | 0.02% signal per mBar |
| **Relative humidity** | 15 – 90% continuous |
| **(Non condensing)** | (0 – 99% intermittent) |
| **Baseline drift** | 0ppm (auto zero) |
| **Long term drift** | <2% signal loss per month |
| **Power source** | Single Alkaline 9 volt PP3 |
| **Main battery life** | >30 hours of continuous use |
| **Internal battery life** | 10 years |
| **Weight** | 180g (Including battery) |
| **Dimensions** | 170 x 60 x 26mm |
| **Display** | 3½ digit LCD |
| **Storage temperature** | -20 to +70 deg Celsius |
| **Storage humidity** | 30% to 90% |

# Technical Support

**Great Britain and World Headquarters**


Micro Medical Ltd

PO Box 6

Rochester

Kent ME1 2AZ

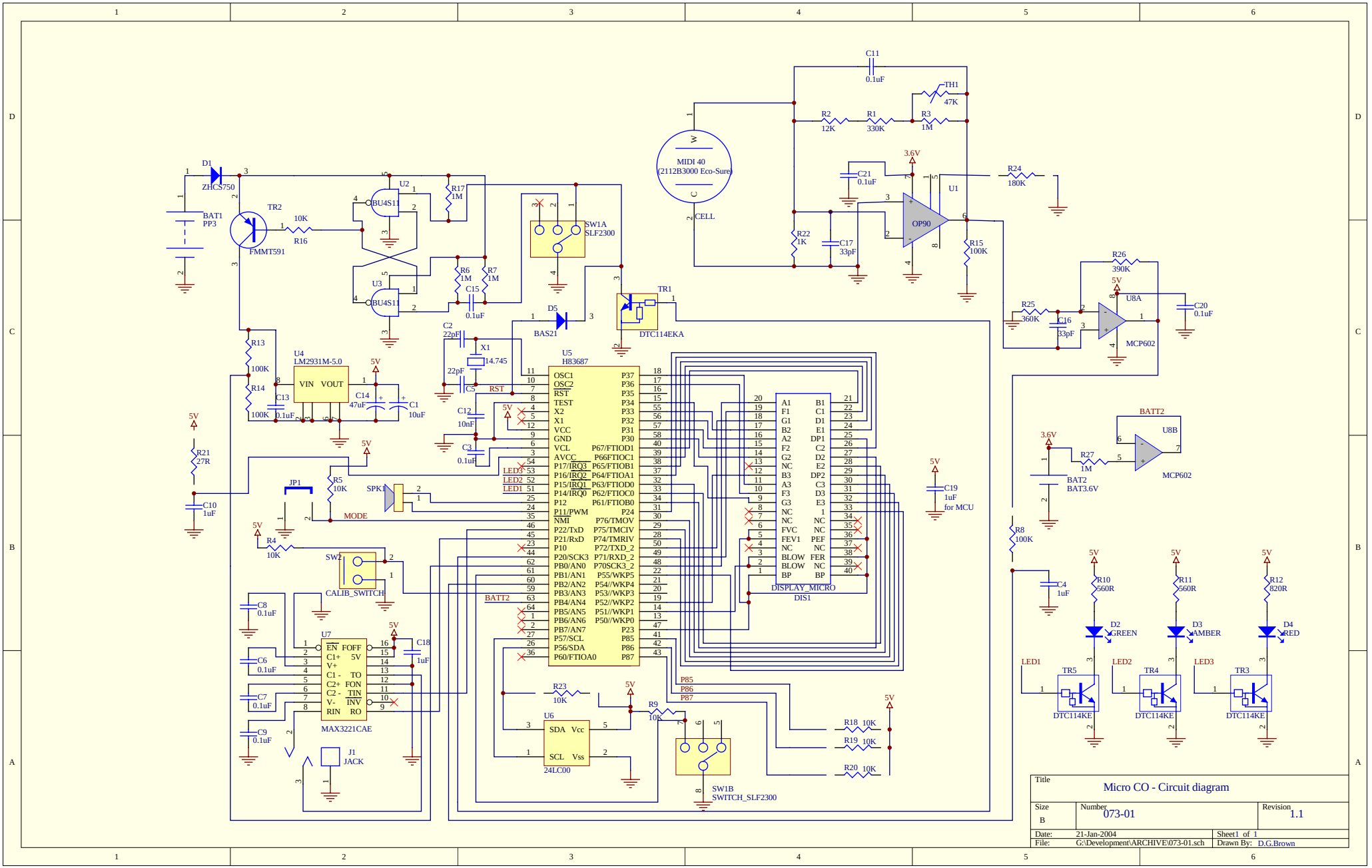
| | |
|---|---|
| Telephone | + 44 (0)1634 893500 |
| Fax | +44 (0)1634 893600 |
| Web Site | http://www.micromedical.co.uk |
| Email | support@micromedical.co.uk |


**Contact Micro Medical Ltd for the local agent in your region or country for local service:**

## Parts List

| Designation | Description |
|---|---|
| U1 | OP90GS. Precision micro power surface mount |
| U2 | BU4S11. Single NAND gate |
| U3 | BU4S11. Single NAND gate |
| U4 | LM2931M5.0. Low drop-out 5 volt regulator |
| U5 | HD64F3687FP. Hitachi microcontroller |
| U6 | 24LC00. 16 Byte surface mount serial EEPROM |
| U7 | MAX3221CAE. Maxim RS232 transceiver |
| U8 | MCP602-I/SN. Microchip dual rail-to-rail OP-AMP |
| D1 | ZHCS750 Schottky diode |
| D2 | 3mm green LED |
| D3 | 3mm red LED |
| D4 | 3mm yellow LED |
| D5 | BAS21. Small signal diode |
| DISPLAY | (LCD 016-03) 3½ Digit custom display |
| TR1 | DTC114EKA NPN transistor |
| TR2 | FMMT591 PNP transistor |
| TR3 | DTC114EKA NPN transistor |
| TR4 | DTC114EKA NPN transistor |
| TR5 | DTC114EKA NPN transistor |
| R1 | 330K Resistor |
| R2 | 12K Resistor |
| R3 | 1M Resistor |
| R4 | 10K Resistor |
| R5 | 10K Resistor |
| R6 | 1M Resistor |
| R7 | 1M Resistor |
| R8 | 100K Resistor |
| R9 | 10K Resistor |
| R10 | 560R Resistor |
| R11 | 560R Resistor |
| R12 | 820R Resistor |
| R13 | 100K Resistor |
| R14 | 100K Resistor |
| R15 | 100K Resistor |
| R16 | 10K Resistor |
| R17 | 1M Resistor |
| R18 | 10K Resistor |
| R19 | 10K Resistor |
| R20 | 10K Resistor |
| R21 | 27R Resistor |
| R22 | 1K Resistor |
| R23 | 10K Resistor |
| R24 | 180K Resistor |
| R25 | 360K Resistor |
| R26 | 390K Resistor |
| R27 | 1M Resistor |
| C1 | 10μF Tantalum capacitor |
| C2 | 22pF Ceramic capacitor |
| C3 | 0.1μF Ceramic capacitor |
| C4 | 1μF Ceramic capacitor |

| | |
|---|---|
| C5 | 22pF Ceramic capacitor |
| C6 | 0.1μF Ceramic capacitor |
| C7 | 0.1μF Ceramic capacitor |
| C8 | 0.1μF Ceramic capacitor |
| C9 | 0.1μF Ceramic capacitor |
| C10 | 1μF Ceramic capacitor |
| C11 | 0.1μF Ceramic capacitor |
| C12 | 10nF Ceramic capacitor |
| C13 | 0.1μF Ceramic capacitor |
| C14 | 47μF Electrolytic capacitor |
| C15 | 0.1μF Ceramic capacitor |
| C16 | 33pF Ceramic capacitor |
| C17 | 33pF Ceramic capacitor |
| C18 | 1μF Ceramic capacitor |
| C19 | 1μF Ceramic capacitor |
| C20 | 0.1μF Ceramic capacitor |
| C21 | 0.1μF Ceramic capacitor |
| TH1 | NTC 47K thermistor |
| SW1 | SLF2300. Double pole 3 position slide switch |
| SW2 | Push switch |
| BAT2 | SL235 CVHZ Sonnenschein 1A-Hr ½ AA Lithium cell |
| X1 | 14.745 MHz crystal |
| CO CELL | 1000 ppm CO fuel cell |


C11
0.1uF
TH1
47K
R2
12K
R1
330K
R3
1M
MIDI 40
(2112B3000 Eco-Sure)
W
C
CELL
3.6V
C21
0.1uF
R24
180K
U1
OP90
R22
1K
C17
33pF
R15
100K
D1
ZHCS750
BAT1
PP3
TR2
FMMT591
10K
R16
U2
BU4S11
U3
BU4S11
R17
1M
R6
1M
R7
1M
C15
0.1uF
SW1A
SLF2300
D5
BAS21
TR1
DTC114EKA
R26
390K
5V
U8A
MCP602
R25
360K
C16
33pF
C20
0.1uF
R13
100K
R14
100K
U4
LM2931M-5.0
VIN VOUT
C13
0.1uF
C14
47uF
C1
10uF
C2
22pF
X1
14.745
22pF
C5
RST
C12
10nF
C3
0.1uF
U5
H83687
OSC1
OSC2
RST
TEST
X2
X1
VCC
GND
VCL
AVCC
P17/IRQ3
P16/IRQ2
P15/IRQ1
P14/IRQ0
P12
P11/PWM
NMI
P22/TxD
P21/RxD
P10
P20/SCK3
PB0/AN0
PB1/AN1
PB2/AN2
PB3/AN3
PB4/AN4
PB5/AN5
PB6/AN6
PB7/AN7
P57/SCL
P56/SDA
P60/FTIOA0
P37
P36
P35
P34
P33
P32
P31
P30
P67/FTIOD1
P66/FTIOC1
P65/FTIOB1
P64/FTIOA1
P63/FTIOD0
P62/FTIOC0
P61/FTIOB0
P24
P76/TMOV
P75/TMCIV
P74/TMRIV
P72/TXD_2
P71/RXD_2
P70SCK3_2
P55/WKP5
P54//WKP4
P53//WKP3
P52//WKP2
P51//WKP1
P50//WKP0
P23
P85
P86
P87
LED3
LED2
LED1
BATT2
DISPLAY_MICRO
DIS1
C19
1uF
for MCU
R21
27R
C10
1uF
JP1
MODE
R5
10K
SPK1
R4
10K
SW2
CALIB_SWITCH
C8
0.1uF
C6
0.1uF
C7
0.1uF
C9
0.1uF
U7
EN FOFF
C1+ 5V
V+
C1 - TO
C2+ FON
C2 - TIN
V- INV
RIN RO
MAX3221CAE
C18
1uF
J1
JACK
R23
10K
U6
SDA Vcc
SCL Vss
24LC00
R9
10K
SW1B
SWITCH_SLF2300
R18 10K
R19 10K
R20 10K
BATT2
U8B
MCP602
R27
1M
BAT2
BAT3.6V
R8
100K
C4
1uF
R10
560R
R11
560R
R12
820R
D2
GREEN
D3
AMBER
D4
RED
LED1
LED2
LED3
TR5
TR4
TR3
DTC114KE
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